How Well can we Control Emissions of Multiple PM Precursors from Coal-fired Power Plants?

Presenter: C. Andrew Miller
U.S. Environmental Protection Agency, Office of Research and Development

research and development

Science Questions

- How can sulfuric acid aerosol formation be prevented or mitigated; what factors govern the formation of sulfur trioxide (SO_3) in combustion systems?
- How do selective catalytic reduction (SCR) and wet flue gas desulfurization (FGD) systems impact the formation and emissions of SO_3 and sulfuric acid (H_2SO_4) aerosol?
- What are the cost-effective alternatives to wet FGD that can now be viably used in an emissions trading environment?
- How well can multiple pollutants be controlled using a single process?

Research Goals

- Identify the factors leading to formation of excessive SO_3 and H_2SO_4 when FGD and SCR systems are installed on coal-fired power plants
  - ✓ Evaluate options to prevent and mitigate visible H_2SO_4 aerosols in the plumes from those plants.
- Identify cost-effective operating regimes for SO_2 controls applied to a wide range of plant sizes and different control efficiencies.
- Determine fundamental behavior of multipollutant control approaches as a guide for improved technology development.

Methods/Approach

Prevention and Mitigation of Sulfuric Acid Aerosol Formation

Figure 1 illustrates that SO_3 is formed relatively easily in a typical coal combustion atmosphere, and the subsequent formation of gas-phase H_2SO_4 occurs as temperatures drop, meaning that where sulfur is present, H_2SO_4 will be present. Because SO_3 formed in SCR catalysts is highly temperature dependent (Figure 2), control of SCR temperature could be one approach to minimize SO_3 formation.

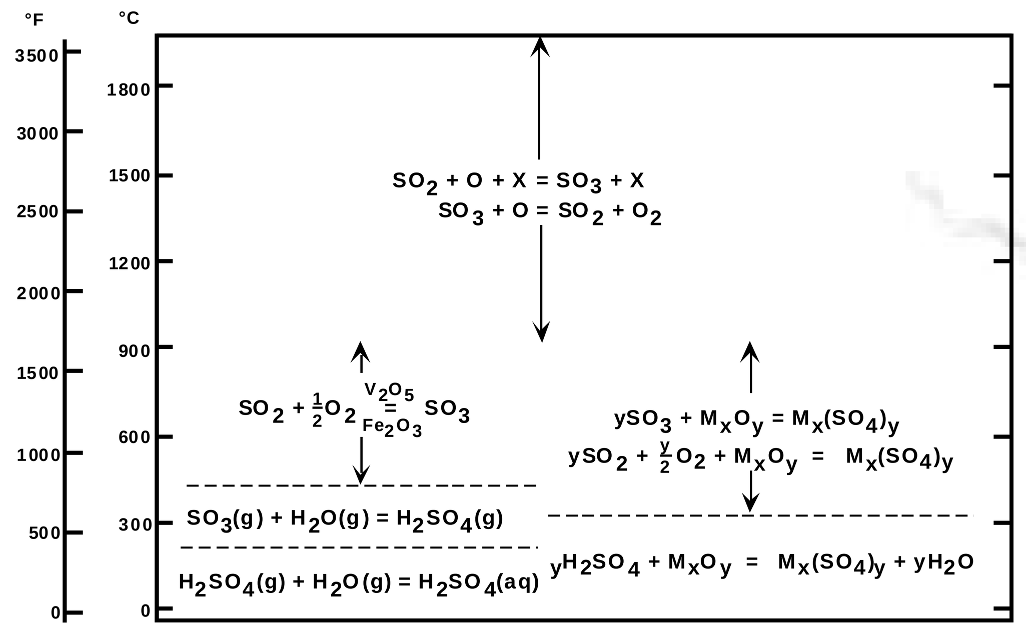

Figure 1. Regimes of SO_3 formation by different mechanisms.

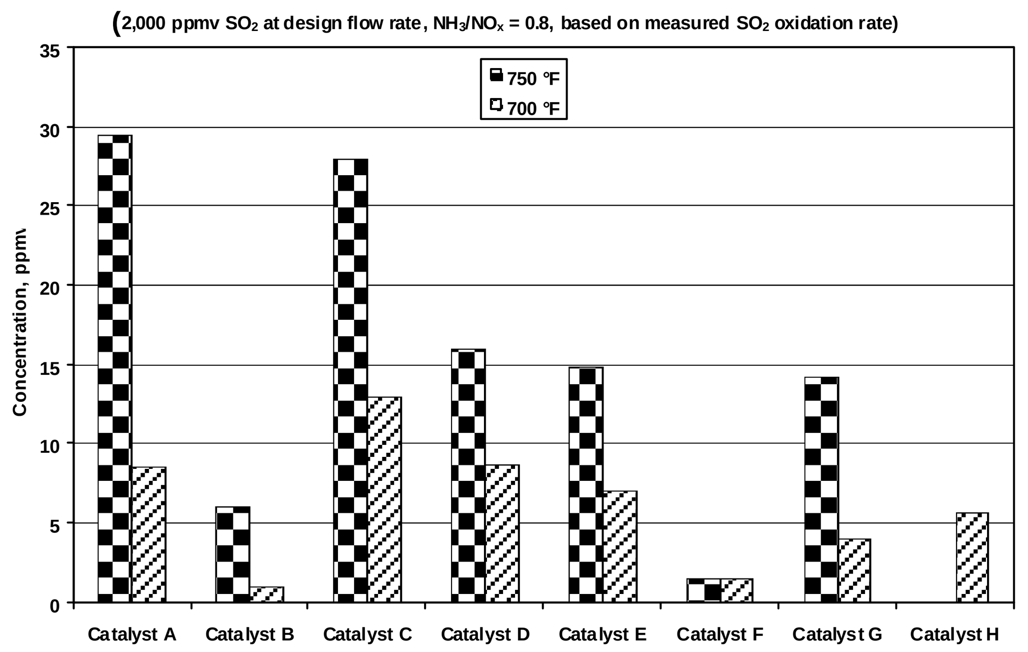

Figure 2. Formation of SO_3 across SCR catalysts.

Alternative SO_2 Removal Technologies: Cost-Effectiveness vs. Removal Efficiency

- As market-based approaches become more common, the key factor in determining the technology to be used will be cost-effectiveness.
- Whereas previous regulatory approaches emphasized percent reduction of emissions, market-based strategies rely upon a mix of technologies to achieve broad national or regional reductions in the most economical way.
- Technologies that were once considered ineffective may now have a much larger role in emission control strategies. Information on control cost for these technologies becomes important in the decision-making process.

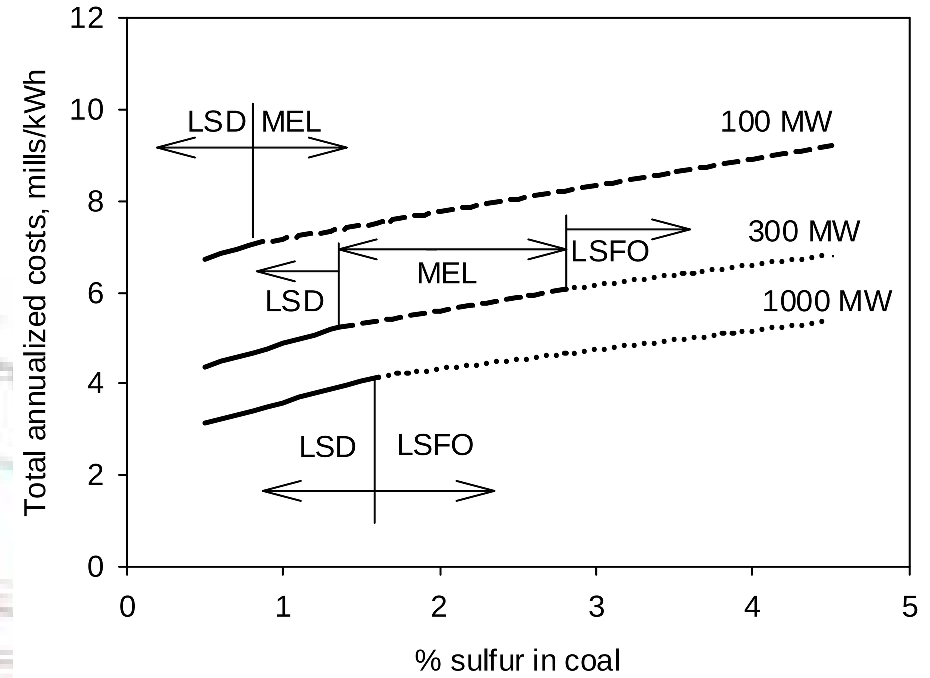

Figure 3. Cost of installation and operation of three SO_2 removal technologies as a function of coal sulfur content and plant size.

Multipollutant Control Technologies

Lime scrubbing for control of SO_2 can be enhanced with injection of ozone (O_3) to achieve simultaneous reduction of NO and Hg. This is one of several proposed multipollutant control approaches, and is being evaluated at EPA's National Risk Management Research Laboratory. Bench-scale testing (Figure 4) is evaluating the fundamental behavior of the system to determine the process's limitations and its most promising operating parameters.

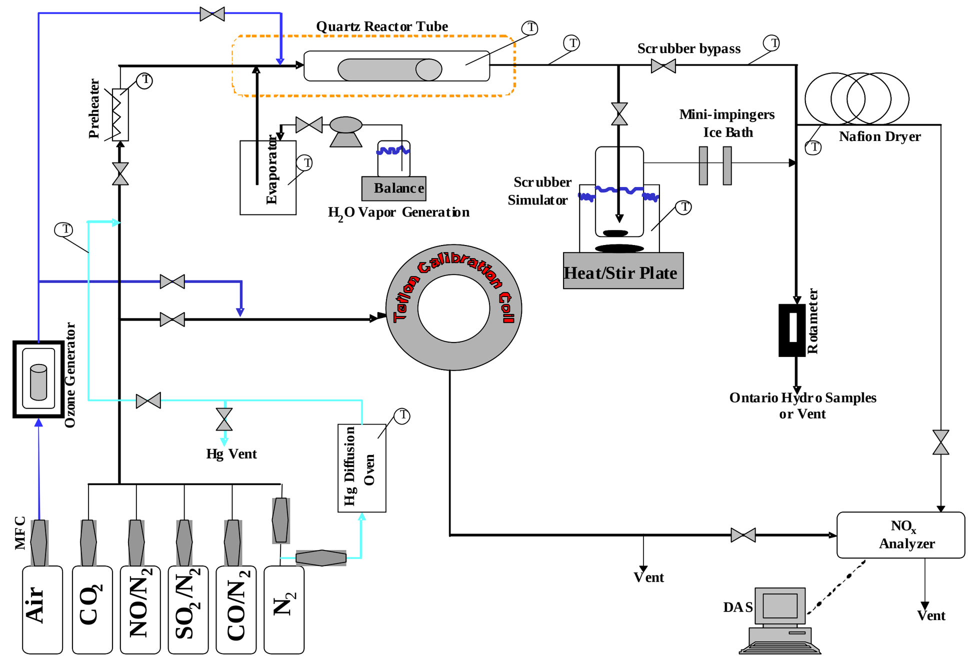

Figure 4. Schematic illustration of the bench-scale system used to evaluate new emission control technologies.

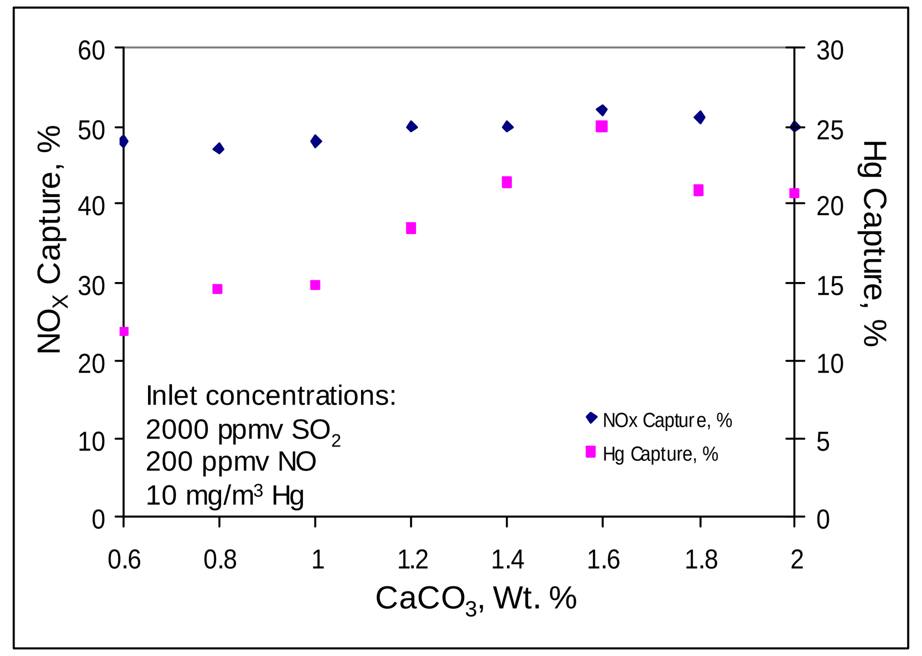

Figure 5. Simultaneous NO_x and Hg removal as a function of lime injection rate at an O_3 injection rate of 1.8:1 O_3:NO (molar ratio).

Results/Conclusions

- The temperature dependence of SO_3 formation is stronger than the temperature dependence of NO_x reduction across SCR catalysts. Temperature control thus provides one means to prevent excessive SO_3 formation in units equipped with SCR systems.
- Understanding the formation processes allows plant designers, operators, and regulators to define appropriate strategies to prevent and mitigate the formation of SO_3 and the subsequent formation of sulfuric acid aerosol in stack plumes.
- Lime spray dryer (LSD) systems will tend to be more cost effective than other system types for plants using lower sulfur (< 1.5%) coals. Magnesium-enhanced lime (MEL) systems are expected to be the most cost-effective for smaller plants. As plant size and coal sulfur increase, limestone forced oxidation (LSFO) systems become increasingly more cost effective compared to the other two system designs.
- At realistic inlet concentrations, O3 injection provides a means to achieve modest NO reduction (about 50%) while simultaneously removing a portion (10-25%) of Hg. These results illustrate the potential for capture of multiple pollutants in a combined process, creating a possibility for more cost-effective pollution control.

Impact and Outcomes

- Provide regulatory agencies with accurate technical guidance on pollution control technology performance and cost, and to provide industry with the fundamental knowledge needed for the successful development of advanced control technologies.
- The expected impacts of this work are to:
  - ✓ reduce the incidence of high concentration H_2SO_4 plumes
  - ✓ quantify the cost-effectiveness of SO_2 control in trading environments
  - ✓ develop the fundamental engineering to support effective combined control of pollutants with a single process
- The expected outcomes of this work are to:
  - ✓ reduce the adverse impact on environments near coal-fired power plants
  - ✓ reduce the cost of achieving national SO_2 reduction goals
  - ✓ increase the availability of commercially offered multipollutant control technologies

Future Directions

The study of factors related to increased SO_3 formation and visible plume formation will be completed in the next year. The future of this effort will be focused on investigation of the fundamental processes involved in control of multiple pollutants.

Air Quality